their accumulation to the bringing of vegetable material from elsewhere by air and by water transport. It follows that the commoner coals have had a similar derivation since they have practically an identical organization.

It may be summarily stated in conclusion, that there is no good evidence that 'coal balls' are organized from material accumulated *in situ*. The facts that they often include isolated masses of charred vegetable matter and that identical material to that composing their substance is often accumulated under modern conditions, by transport and sedimentation in open water, furnish very strong evidence of their formation from transported material. Further the coals in which 'coal balls' have been found are abnormal coals singular by the absence of spore material which is a striking feature of the organization of typical coals of every geological age and all geographical regions. The structure of the coals containing the 'coal balls' cannot consequently be used as an argument in favor of the *in situ* origin of coals in general, even if it were proved that they themselves had been accumulated in this manner, which, as has been shown above on the basis of the organization of 'coal balls,' is very far from being established. The great mass of coals by their close resemblance in organization to cannels show that they have been laid down under the open water and transport conditions, which are universally conceded for the coals of the canneloid category. A fuller account with evidence in greater detail will appear at a later date.

[1] Jeffrey, E. C., Economic Geology, **9**, 1914, (730–742).
[2] Jeffrey, E. C., *Chicago J. Geol. Univ. Chic.*, **23**, 1915, (218–230).
[3] Jeffrey, E. C., *Science Conspectus, Boston*, **6**, 1916, (71–76).
[4] Stopes and Watson, *London Phil. Trans. R. Soc.*, B. **200**, 1907, (167–218).

THE EFFECT OF DEGREE OF INJURY, LEVEL OF CUT AND TIME WITHIN THE REGENERATIVE CYCLE UPON THE RATE OF REGENERATION

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1. Degree of Injury.—In a former series of papers the writer gave the results of experiments on the effect of degree of injury upon the rate of regeneration. A number of different species of animals and various combinations of injuries were involved. The results obtained tend to show that on the whole, within certain limits, the rate of regeneration

from an injured surface is not retarded by simultaneons regeneration in other parts of the body. Where a difference exists between the rates with and without additional injury there is usually an advantage in favor of the part with additional injury. The differences are however slight and in some cases come within the limits of probable error. It is only when the data are taken as a whole that it is possible to judge of the correctness of the general conclusion that within fairly wide limits of additional injury there is certainly no decrease in rate of regeneration but rather a tendency toward an increase.

Additional data on these points have been obtained and a further analysis of the problem was made with a view to the determination of the effect of additional injury to a like organ as compared with additional injury to an unlike organ.

Two of the six experiments will be mentioned here. In the first the experiment consisted in the determination of the length of the regenerating right fore-leg of the salamander, Amblystoma punctatum, under three degrees of injury; (1) when the right fore-leg alone is removed, (2) when its mate is also removed, and (3) when its mate and one-half of the tail are removed. The second degree involves the removal of additional material of the same kind and the third a further removal of material of a different kind. In every case it is the regeneration of the fore-leg that is used as the basis of comparison.

At two days the average regenerated lengths of the fore-leg are respectively 0.13, 0.16 and 0.15 mm. for the three degrees of additional injury; at four days the corresponding values are 0.22, 0.36 and 0.29; at six days 0.42, 0.53 and 0.55; at eight days 0.66, 0.83 and 0.73; at ten days 0.91, 1.34 and 1.24; at twelve days 1.48, 1.60 and 1.61; at fourteen days 1.98, 2.19 and 2.29; at sixteen days 3.02, 3.01 and 3.08; and at nineteen days 3.84, 3.64 and 3.90. In no case does the removed fore-leg with no additional injury to the animal give the highest value for regeneration. In all but two of the cases it has the lowest value.

The comparisons show that the regeneration of a fore-leg is not as rapid as when the individual is regenerating no other part of the body as it is when the other fore-leg is being regenerated at the same time. There is, however, no essential difference between the effect of additional injury of a fore-leg and an additional injury of a fore-leg plus one-half of the tail. It may be that the effect of additional removal is confined to removal of a similar part. On the other hand, the accelerating effect may be found only within certain degrees of injury, the limit being exceeded by the highest of the three degrees.

In order to test further the view that the accelerating effect may be confined to additional removal of a similar organ a comparison was made of the regenerating tail lengths following removal of one-half of the tail under the two degrees of no additional injury and of removal of the two fore-legs. In such a case there is no difference in rate of regeneration of the tail.

These experiments, together with others that have been made, when taken as a whole show that a part regenerates slightly more rapidly when additional material of the same kind is removed than when the part alone is removed. Simultaneous removal of tail material, however, may not accelerate the regeneration of a leg and simultaneous removal of a leg may not accelerate the regeneration of the tail. The rate in these cases is, however, not decreased by the additional injury. The statement may therefore be made that within limits the regeneration of a part is not retarded by simultaneous removal and regeneration of material in other parts of the body. When this additional material is of the same kind as that whose rate is being studied there may even be an acceleration of regeneration.

2. *Level of Cut.*—That the level of the cut has an important influence upon the rate of regeneration has been made out by a number of investigators. Their work indicates that regenerations from deeper levels are on the whole more rapid than from more superficial ones. The present data confirm this conclusion and make possible a further analysis of the relation. They show that within wide limits the length regenerated in the tail of an Amphibian larva is directly proportional to the length removed. Within these limits therefore the length regenerated per unit of removed length is a constant.

First and second regenerations of the tail in the tadpoles of Rana clamitans and first regenerations in the salamander, Amblystoma punctatum, give essentially the same results. Second regenerations of the frog will be taken as an example. The removed tail lengths were 1.5, 2.8, 4.9, 8.4, 13.1 and 18.1 mm. or respectively 6, 10, 18, 31, 49 and 67% of the original tail lengths. The regenerated lengths for these six levels ten days after the operation were respectively 1.0, 1.3, 1.4, 2.3, 3.7, and 5.1 mm., an increase for each increase in depth of the level of injury.

The specific lengths or lengths regenerated per unit of removed length as calculated from these values are respectively 0.67, 0.46, 0.29, 0.28, 0.28 and 0.28, a close approach to constancy for removed lengths of 4.9 to 18.1 mm. Figures 1 and 2 give graphic representations of these results.

An analysis of the progress of regeneration from the time of the operation to the completion of the process shows that the proportional increase in regenerated length with the increase in removed length and resultant constancy in specific regenerated length applies only to the material produced by active cell division. During the first four days in frog tadpoles, when the regenerating part is made up almost entirely of cells that have migrated from the old tissues without division, there is no such relation. The length of new material at this time is not strikingly different for the different levels and the process seems to be a local response of the cells to the injury.

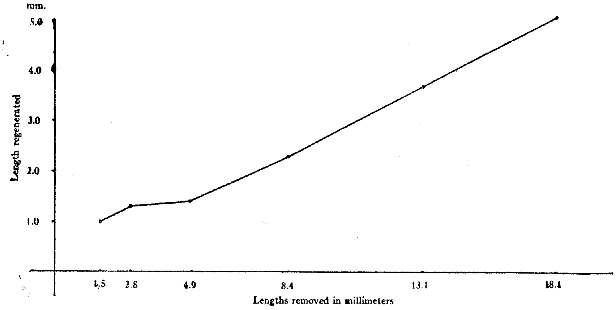

FIG. 1. RANA CLAMITANS. SECOND REGENERATIONS. TEN DAYS

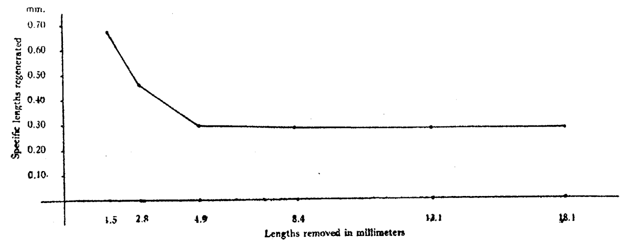

FIG. 2. RANA CLAMITANS. SPECIFIC REGENERATED LENGTHS. TEN DAYS

A complication in the relation between regeneration and level of the cut is introduced by the fact that the regenerated tail is not as long as the original one. A certain per cent only of the removed length is replaced, 40% or less for all except the levels near the tip. Also, the end of the process is reached sooner for the shorter than for the longer removals. From the deepest levels regeneration is still proceeding when it has stopped from the medium and shallowest ones. When all regenerations are completed the specific lengths are therefore slightly greater for the longest removals than for the medium ones.

As to the cause of the greater rates at the deeper levels little more can be said than that it does not seem to be due to inherent differences

in the cells at the different levels. If differentiation in the tail proceeded from the tip toward the base, the more rapid rates from the more basal levels might be explained by the more embryonic character of the cells at these levels. As the tip is approached the material would become more and more highly differentiated and therefore less and less capable of readjustment. There is however no evidence that differentiation proceeds in this way in this case.

The progressive increase in rate with depth of level of the cut is undoubtedly due to reactions which involve a more central control, a coördination of the functional activity as a whole. The period of cell migration probably is only slightly subject to such control. It is a period in which the response is largely local in character. The rate of cell division which is the important factor during the period of rapid increase in length is however undoubtedly under central control.

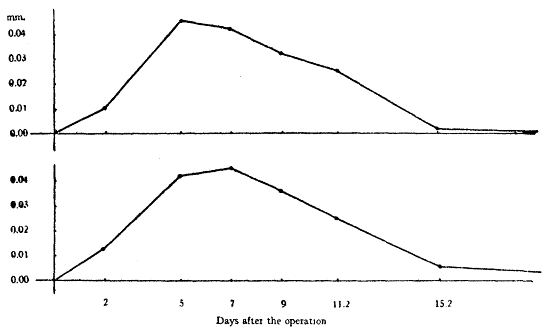

FIG. 3. SPECIFIC RATES OF FIRST AND SECOND REGENERATIONS AT DIFFERENT TIMES AFTER THE OPERATION. RANA CLAMITANS TAIL REGENERATION. UPPER FIGURE = SECOND, LOWER FIGURE = FIRST REGENERATION.

3. Time within the Regenerative Cycle.—The present analysis of change in rate of regeneration during the regenerative cycle was made in extension of previous studies which showed that the increase in amount of material during regeneration follows the general rule of increase during an ordinary life cycle. The rate is slow at first, increases very rapidly to a maximum, then declines rapidly at first and then more and more slowly as zero is approached.

The present study deals with tail regenerations in frog and salamander larvae. Large tadpoles of Rana clamitans which remained fairly constant in size during the course of the experiment were found to be the most satisfactory. They yielded results which were uniform enough for an analysis of the change in rate. The second regenerations are taken up here. The levels of removal averaged 1.5, 2.8, 4.9, 8.4,

13.1 and 18.1 mm. from the tip or respectively 6, 10, 18, 31, 49 and 67% of the tail length.

Since the specific regenerated length or length regenerated per unit of removed length is a fair constant for all levels between 4.9 and 18.1 mm. the most reliable data on change in rate are obtained by averaging the specific rates for all the individuals with these levels of injury. The average specific rates per day obtained in this manner are 0.010 mm. for the 0–4 day period, 0.045 for the 4–6 day period, 0.042 for 6–8

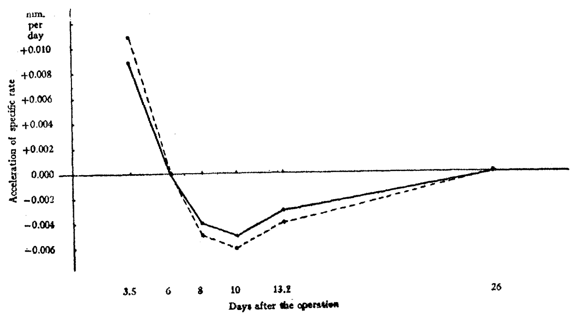

FIG. 4. ACCELERATION OF SPECIFIC RATE. FIRST AND SECOND REGENERATIONS OF THE TAIL IN RANA CLAMITANS. UNBROKEN LINE = FIRST REGENERATION. BROKEN LINE = SECOND REGENERATION.

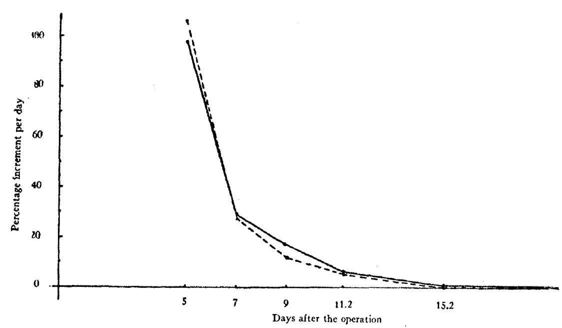

FIG. 5. PERCENTAGE INCREMENT PER DAY AT DIFFERENT PERIODS AFTER THE OPERATION. FIRST AND SECOND REGENERATIONS OF THE TAIL OF RANA CLAMITANS. UNBROKEN LINE = FIRST REGENERATION. BROKEN LINE = SECOND REGENERATION.

days, 0.032 for 8–10 days, 0.025 for 10–12½ days, 0.002 for 12½–18 days and 0.000 for 18–56 days (fig. 3). The specific rate reaches its maximum just before the end of the sixth day.

The values for acceleration of specific rate are +0.011 mm. from the 0–4 to the 4–6 day period, 0.000 from the 4–6 to the 6–8 day period, −0.005 from the 6–8 to the 8–10 day period, −0.006 from the 8–10 to the 10–12½ day period, −0.004 from the 10–12½ to the 12½–18 day period and 0.000 from the 12½–18 to the 18–56 day period (fig. 4).

The only plus value comes between the first two periods and the lowest values are between the 8–10 and the 10–12½ day periods.

An examination of these values and a comparison with the facts of histogenesis shows that acceleration of rate is a plus quantity only during the period before active differentiation of the cells has begun. The retarding effect is evident with the beginning of apparent tissue differentiation and by the ninth to eleventh days the negative acceleration is at its height.

The percentage increments for the six periods represented are respectively 106, 28, 12, 5, 0 and 0 (fig. 5). There is a very rapid decrease at first and then a slower and slower one as zero is approached. The data agree with those of ordinary growth.

First regenerations of frog tadpoles gave results which were essentially similar to those for second regenerations.

The data will appear in full in the *University of Illinois Biological Monographs.*

PRELIMINARY NOTE ON THE DISTRIBUTION OF STARS WITH RESPECT TO THE GALACTIC PLANE

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A significant feature of the distribution of stars over the face of the sky is their concentration toward the plane of the Galaxy. Approaching the Milky Way from either side, we find that objects of all degrees of brightness become more and more numerous; with decreasing galactic latitude, the star-density regularly increases and attains a maximum in the star clouds of the Milky Way itself, a fact long known and, as early as 1750, the basis of cosmological speculation by Thomas Wright of Durham.[1] The phenomenon was studied by both the Herschels, and more recently Seeliger, Celoria, Pickering, Kapteyn,[2] and Chapman and Melotte,[3] among others, have given values of the stellar density; and yet, from a numerical standpoint, the matter remains even now more or less an open question.

Our knowledge of stellar distribution must include the total number of stars per unit area at each galactic latitude, and, as well, of the number for each interval of magnitude from the brightest to the faintest; moreover, the magnitudes themselves must be homogeneous and in accordance with a uniform scale. The Herschel counts, giving only totals to a certain limit near the 14th magnitude, do not satisfy these